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# Establishment of a field school for weed ecology and management

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**Abstract**
Multiyear field experiments using three crop rotations, two of which were low-external-input (LEI) systems, showed that cropping systems can be designed to achieve large reductions in agrichemical use while providing effective weed control and high yields and profits.

**Keywords**
Agronomy, Multi-year rotations low-external input, Economic and environmental impacts, Soils and agronomy, Weed control alternatives

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## Principal Investigator:

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**Co-investigator:**
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**Budget:**
$34,250 for year one
$37,396 for year two
$38,475 for year three

Q Can diversified, low-external-input (LEI) cropping systems produce yields and profits that match or exceed those obtained from conventional systems?

ECOLOGY

A These results show that diversified LEI systems can produce yields and profits that match or exceed those obtained from conventionally managed corn-soybean systems. Additionally, we learned that ecological processes such as weed seed consumption by rodents and insects can promote effective weed control in LEI systems, while allowing substantial reductions in herbicide use. Weed seed losses to rodents and insects can be enhanced by delaying tillage operations to leave seeds on the soil surface for as long as possible.

## Background

Iowa farmers are looking for ways to produce enough crops and income while protecting the environment. Using large quantities of synthetic fertilizers and herbicides can help yields, but also pollutes surface and groundwater. Investigators for this project sought to determine whether weed suppression, crop yield, and profit characteristics of diversified, low-external-input (LEI) systems can match or exceed those of a conventionally managed system.

The project had three principal objectives and corresponding sets of activities:

- Determination of the impacts of three contrasting crop rotation systems on weeds, crop yields, and economic costs and net returns, using large-scale field plots established at the ISU Marsden Farm. Special attention was paid to the effects of weed seed consumption by rodents and insects.
- Establishment of small plots to demonstrate the effects of a cultural management practice (stubble mowing) and an ecological process (weed seed predation) on weed seed production and seed survival. These plots were near the core cropping systems study area and were used to encourage dialogue with farmers and agricultural professionals about what they observed.
- Organization and delivery of in-field and indoor learning activities focused on weed ecology, cropping system diversity, and economic costs and returns of conventional and alternative management systems.

## Approach and methods

The core cropping systems experiment was conducted at the Iowa State University Marsden Farm in Boone County. The site had previously been in a corn-soybean rotation and received conventional fertilizer and herbicide inputs. The entire site was planted to oat in 2001 and the cropping systems study was established in 2002.

*Aeriel view of research plots.*

In addition to a conventional two-year corn-soybean rotation, the experiment included two LEI systems: a three-year corn-soybean-small grain + red clover rotation and a four-year corn-soybean-small grain + alfalfa-alfalfa rotation. Spring triticale was used as the small grain in 2003-2004, and oat was used in 2006. Synthetic fertilizers were applied in three- and four-year rotations, but at lower rates than in the conventional two-year rotation. Weed management in the two-year rotation was based on conventional rates of herbicide applications, whereas in the three- and four-year systems, herbicides were applied in bands in corn and soybean, greater reliance was placed on cultivation, and no herbicides were applied in small grain and forage legume crops.

## Results and discussion

Over the period from 2003 to 2006, synthetic N fertilizer use was 59 and 74 percent lower in the three- and four-year LEI systems, respectively, than in the conventional two-year system. Herbicide use was reduced 76 and 82 percent in the three- and four-year systems compared to the two-year system.

Weed dry matter production was low in all systems and seed densities of two key weed species, giant foxtail and velvetleaf, declined or remained unchanged in all systems. Thus, lower herbicide inputs did not lead to increased weed problems. Seed predation by insects and rodents was found to be an important factor in regulating weed density.

Corn and soybean yields were as high or higher in the LEI systems as in the conventional system, and matched or exceeded average yields on commercial farms in Boone County.

Without government subsidy payments, net returns were highest for the four-year LEI system ($540 $ha^{-1}$ $yr^{-1}$), lowest for the three-year LEI system ($475 $ha^{-1}$ $yr^{-1}$), and intermediate for the two-year conventional system ($504 $ha^{-1}$ $yr^{-1}$). With crop subsidies, differences among systems in net returns were smaller as subsidies favored the conventional system, but the rank order of the systems was maintained.

## Conclusions

This study showed that productive and profitable LEI cropping systems are based on optimizing overall system performance by fitting together individual crop components. For example, though triticale and oat themselves added little revenue to the four-year rotation system, they served as effective nurse crops for establishing alfalfa. This minimized erosion, suppressed velvetleaf growth without herbicides, and provided habitat for the seed predators that attacked velvetleaf and giant foxtail seeds. Alfalfa was less profitable than corn, but its inclusion in the rotation system allowed significant reductions in N use for corn, while also suppressing velvetleaf seed production and fostering weed seed predators.

In both field experiment and demonstration trials, insect and vertebrate seed predators were shown to remove large quantities of weed seeds in both warm and cold seasons.

*Weed seed remover.*

Modeling analyses of weed population dynamics indicate that these weed seed removal rates could suppress weed densities, especially in low-external-input systems.

If a future goal is to satisfy multiple performance criteria for agriculture, including enhanced crop productivity, satisfactory profitability, and improved environmental protection through reduced use of agrichemicals, continued attention to the design and performance characteristics of LEI systems will be required.

## Impact of results

To share the results widely, the PIs organized and delivered in-field and indoor learning activities focused on weed ecology, cropping system diversity, and economic costs and returns from conventional and alternative management strategies. These activities were targeted at farmers, extension educators, private sector agricultural professionals, and scientists. Farmers and agricultural professionals who returned surveys after these workshops had positive responses to the information that was provided.

The project is continuing with additional investigations of energy use, soil quality and weed population dynamics. Further economic analyses will be conducted to determine the impacts of rapidly changing crop prices and input costs, and more fully integrating crop and livestock enterprises.

## Education and outreach

Project participants gave no less than 39 presentations on their work to scientific and agricultural audiences between July 2004 and July 2007. Among the places where reports were made about the project: Weed Science Society of America annual meeting, several ISU field days, American Society of Agronomy annual meeting, European Weed Research Society, University of Illinois, University of Wisconsin, Princeton University, Pennsylvania State University, Practical Farmers of Iowa meetings, North Central Weed Science Society meeting, Entomological Society of America meeting, and the Ecological Society of America meeting.

Two ISU graduate students, Andrew Heggenstaller and Megan O'Rourke, completed M.S. theses related to the project findings. An ISU undergraduate, Katherine Edwards, completed a special project ("An 'undercover' investigation of seed predation for velvetleaf and giant foxtail") using the Marsden Farm plots. Two international visitors, one from Italy and one from Uruguay, participated in field work for the project.

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